Fundamental and Applied Research of Nano-Particle Measurement

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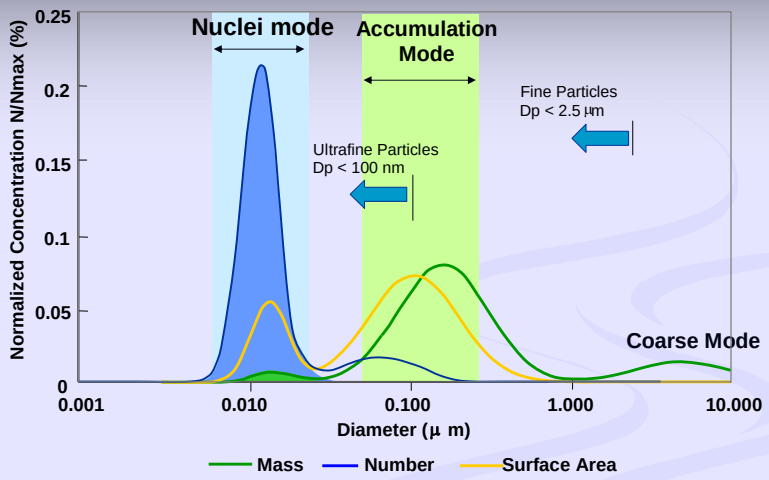
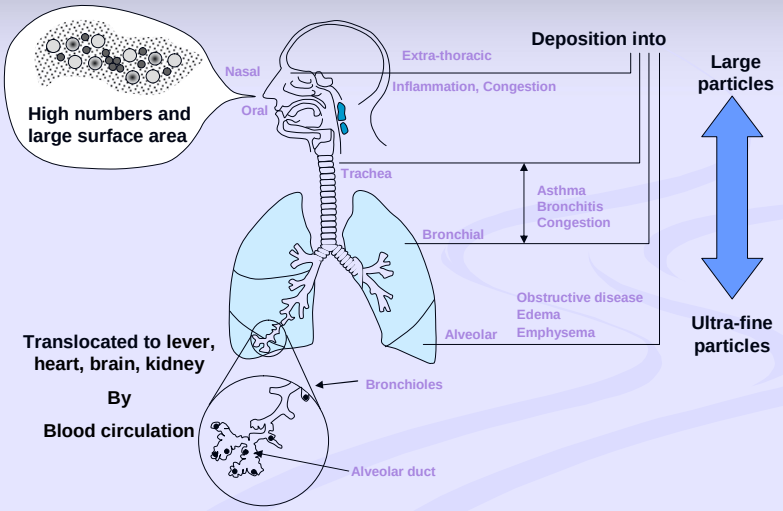
What is nano Particle?



Source: David Kittelson

Why do we need to consider nano PM?

Human body significantly reacts to diesel nano-particles.
Small particles are too dangerous to nervous system.



Problems of Nano-PM Measurement

There are many different instruments available for counting particles under steady state and transient conditions. None of them can give very accurate and repeatable results.

Because

Nano-particles are very unstable and sensitive to dilution process and ambient condition such as temperature, humidity and residence time.

Necessity

To make the nano-particles characteristically stable so that accurate and repeatable measurement will be possible.

Fundamental Research

July 12, 2006 International Seminar – Next Generation Energy Conversion System
at Doshisha Univ., Kyoto

Motivation

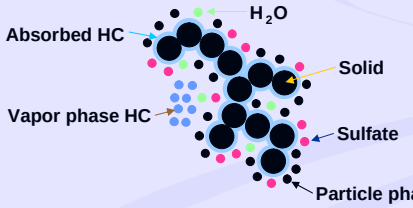
Discussion started in the PMP under the auspices of GRPE

PMP Recommendation

Thermal Conditioning of exhaust gas in order to restrain the fluctuation in nano-particle measurement

Objective of ThC

Vaporizing and eliminating the volatile fractions



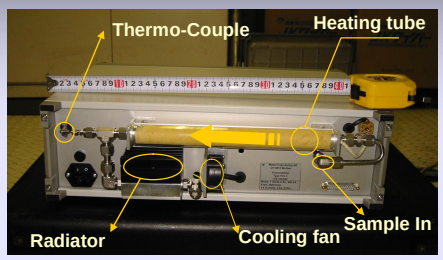
Objective

**It is a newly developed device
The characteristics of the thermo-conditioned nano-particles are completely unknown under different ambient and engine operating conditions.**

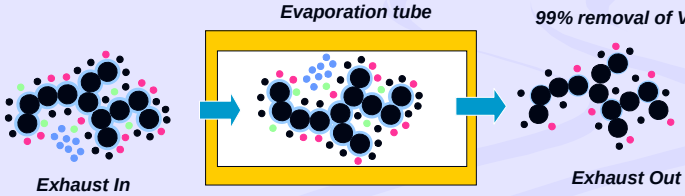
To investigate

- ***Effect of thermo-conditioner/evaporator on the nano particles***
- ***Clarify the thermo-physical behavior of the conditioned nano particles***
- ***Testing the stability and repeatability of nano particles measurement***
- ***Clarify the characteristics of nano-particle and build up the Nano-Particle Model from thermal behavior.***

Thermo-Conditioner

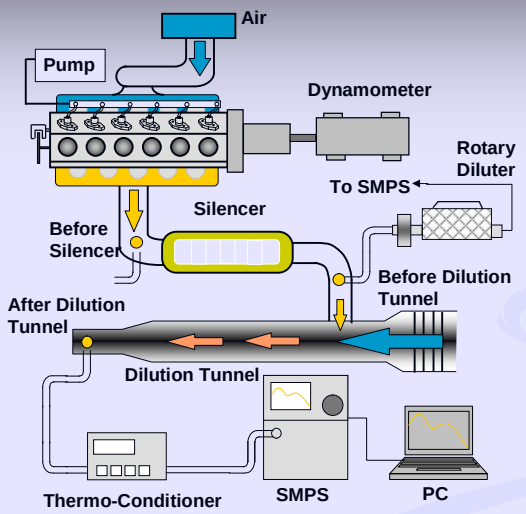


Specifications of ThC	
Dimension (mm)	400 x 132 x 448
Flow rate	1 to 5 Liter/min
Heating range	0 to 400 ° C



Basic Function of ThC

Experiment System



Engine specification

Engine type	DI Diesel
Injection system	Common rail
Bore X Stroke	114 X 130 mm
Swept volume	7.96 Liter
Emission standard	Japan 1998
Max Power kW/rpm	191/2700
Max Torque Nm/rpm	745/1600

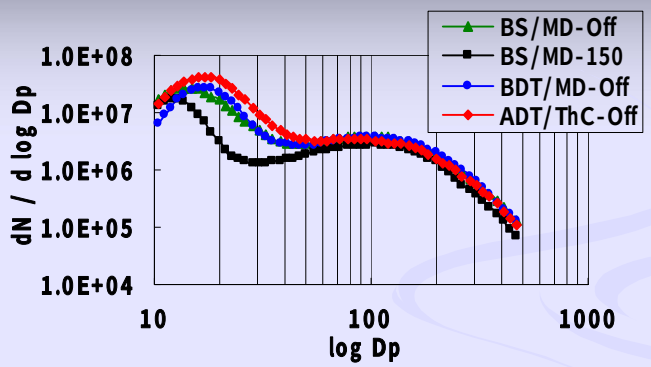
Test Conditions

Idling	550 rpm 0 N-m
Low load	1200 rpm 98 N-m
Medium load	1620 rpm 460 N-m

Results and Discussion

- Effect of Sampling Points
- Effect of Hot Dilution Temperature
- Effect of Thermo-Conditioner

Effect of Sampling Point on Nano-PM



Idling Condition:
Speed: 550 rpm
Torque: 0 N-m

BS: Before Silence
BDT: Before Dilution Tunnel
ADT: After Dilution Tunnel

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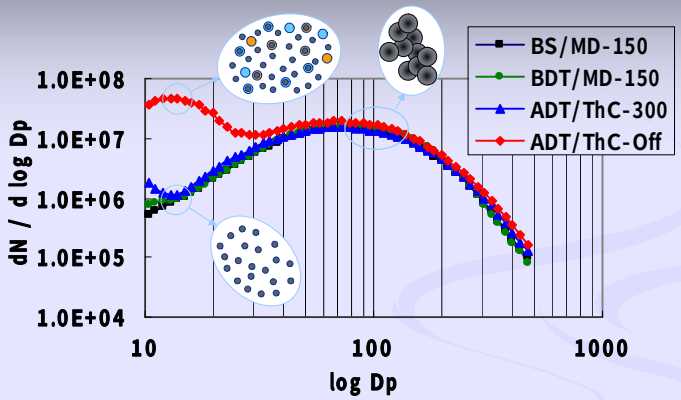
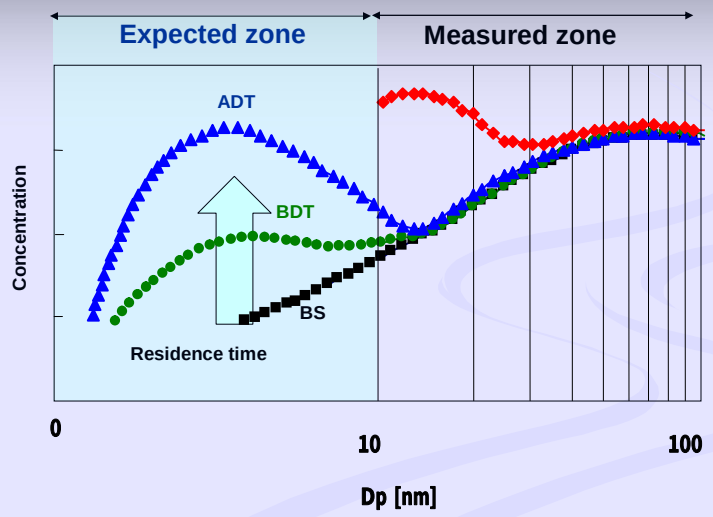
Effect of Sampling Point on Nano-PM



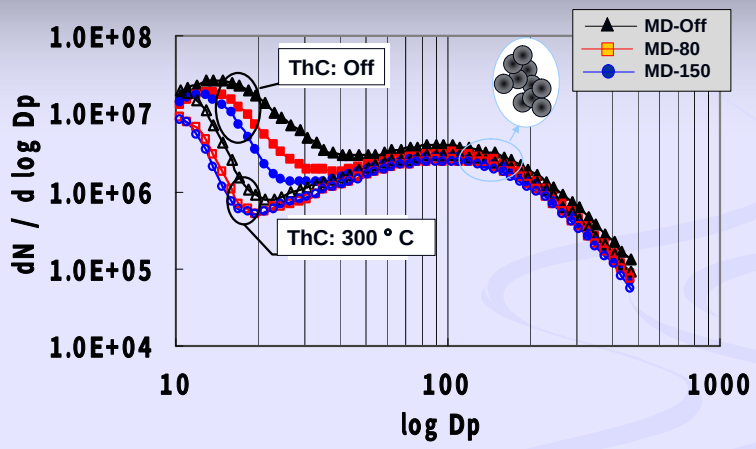
Low load Condition:
Speed: 1200 rpm
Torque: 98 N-m

BS: Before Silence
BDT: Before Dilution Tunnel
ADT: After Dilution Tunnel

Nano-PM Smaller than 10 nm

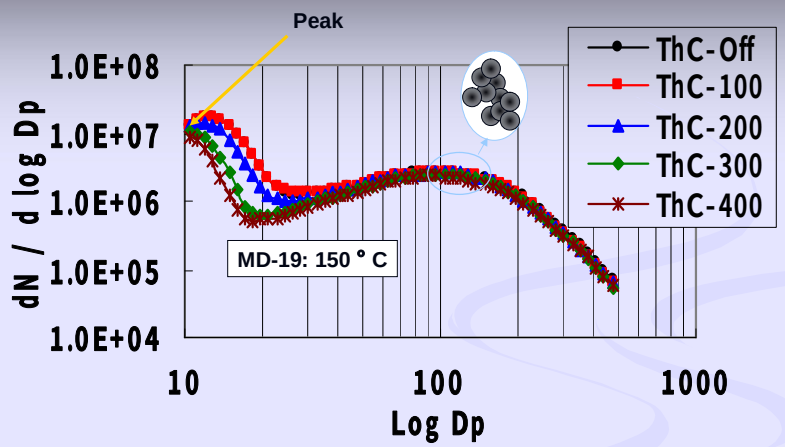


Effect of Dilution Temperature on Nano-PM



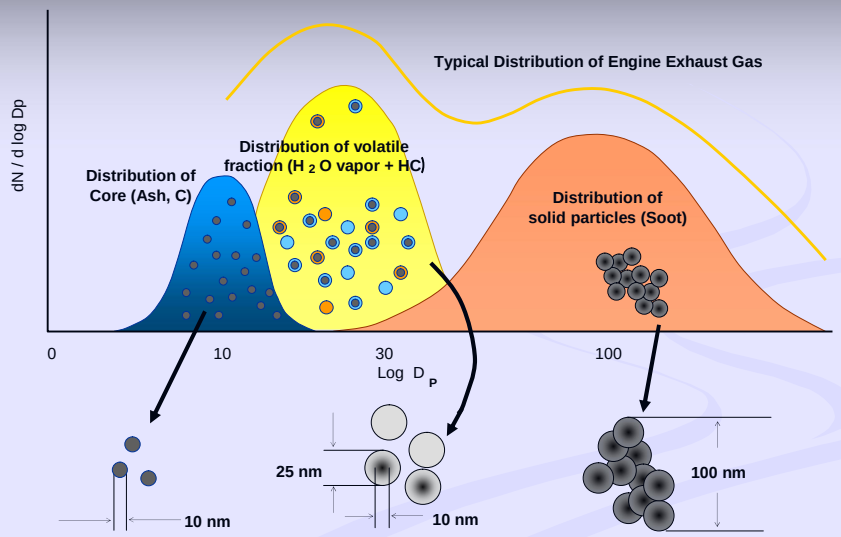
Sampling point: Before silencer
Idling condition: 550 rpm, 0 N-m

Effect of Thermo-Conditioner on Nano-PM



Sampling point: Before silencer
Dilution: Hot at 150 C
Idling condition: 550 rpm, 0 N-m

Nano-Particle Model

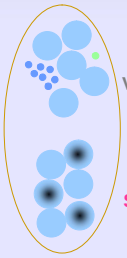


Types of Nano-Particles

±100 nm
Solid particles (soot)
Agglomerate of soot

Accumulation mode particles:

These cannot be vaporized/desorbed significantly by thermal-conditioning.



15~30 nm
Volatile particles

Nuclei-mode particles:

Nucleate due to cold dilution but vaporizes/desorbs under thermo-conditioning even at 100 °C

15~30 nm
Semi-volatile particles

Nucleate due to cold dilution but vaporizes/desorbs slightly or becomes smaller in size under thermo-conditioning at 100~300 °C

<=10 nm
Ash/Carbon/Heavy HC

Do not vaporize/disrobe or change in size under thermo-conditioning even above 400 °C

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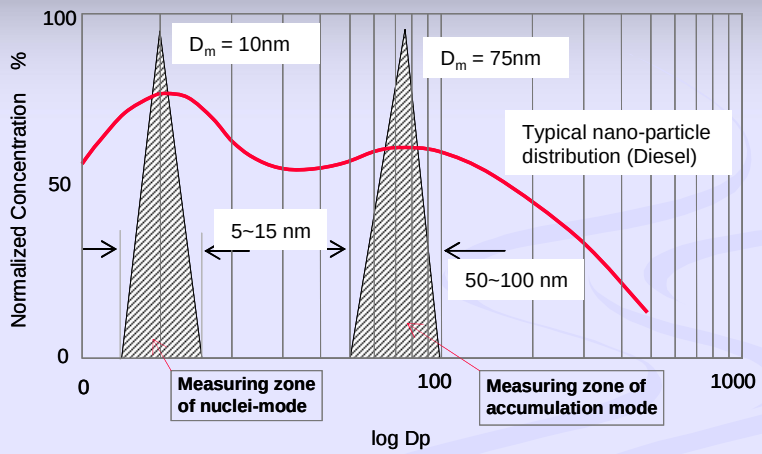
at Doshisha Univ., Kyoto

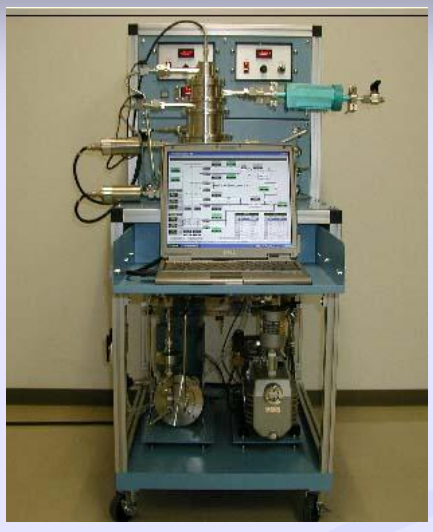
Applied Research

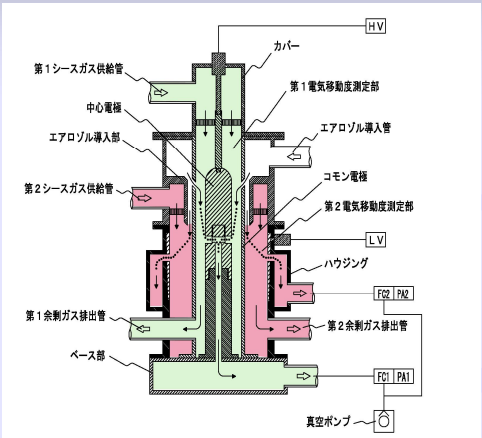
National Traffic Safety and Environment Laboratory, JAPAN NTSEL

Concept of New Measurement Device

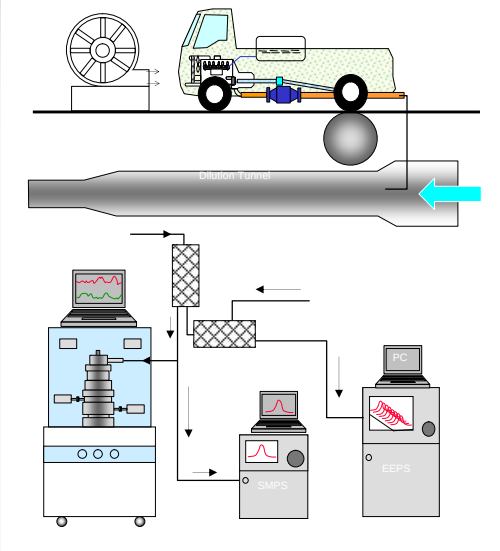


Dual-type DMA





Experimental setup



Influence of Oxidation Cat.

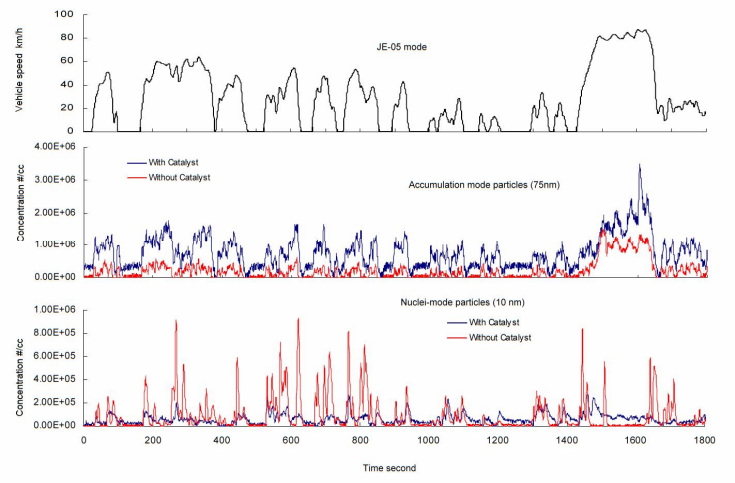
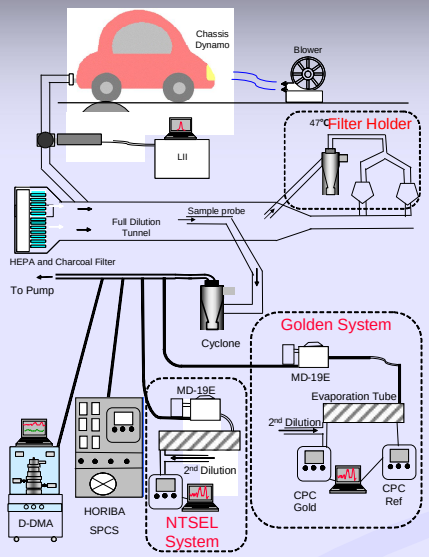
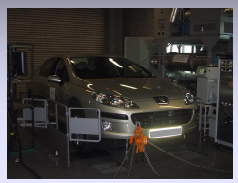


図 9-2 全量希釈トンネル後の排出ナノ粒子の挙動（酸化触媒有無の影響）

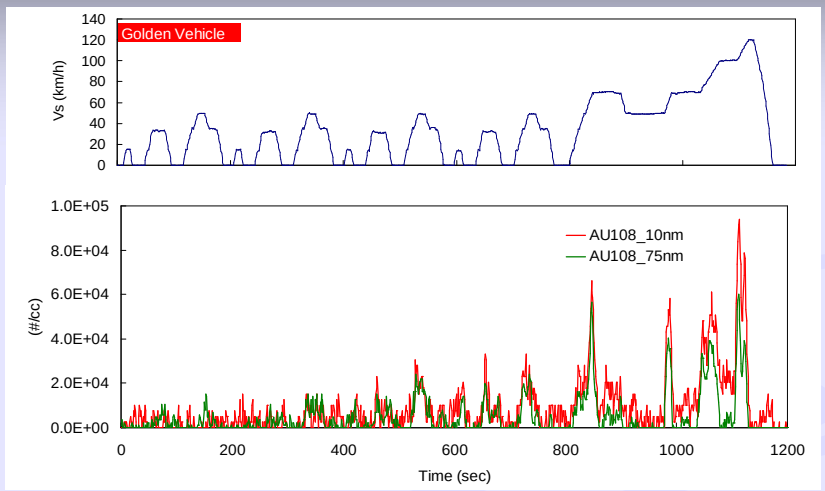
Comparative Experiment





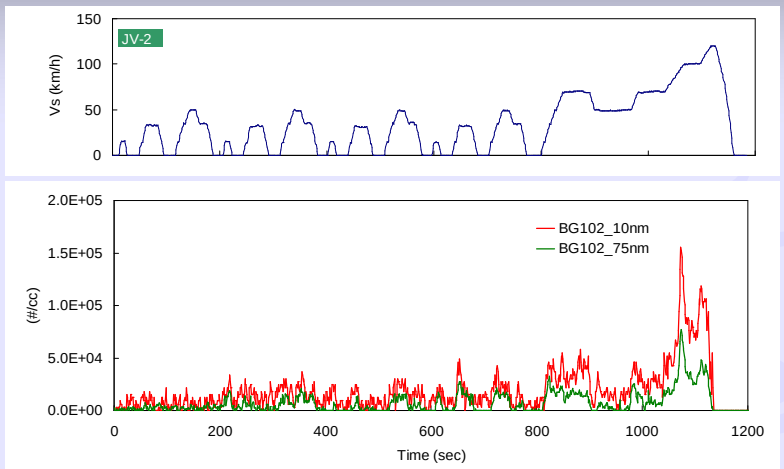
Result from Dual-DMA

European Small Diesel Vehicle

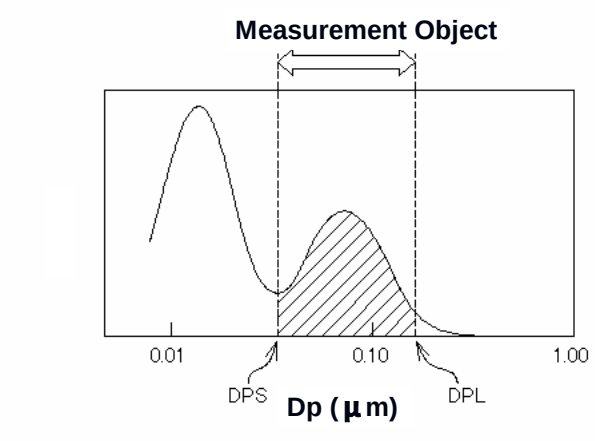


Result from Dual-DMA

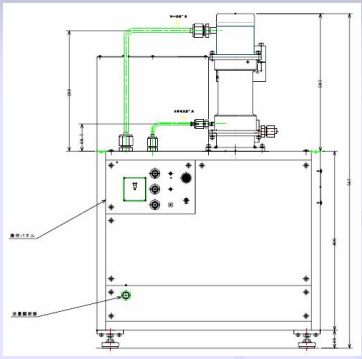
Gasoline Direct Injection Vehicle



Concept of Popularized Nano-particle Measurement Device



Popularized Nano-particle Measurement Device



Conclusions

Nuclei-mode particles having the diameter of about 15-30 nm is significantly influenced by the thermal conditioning temperature while the accumulation mode particles having the diameter of about 100 nm remain almost the same.

Thermo-conditioner can vaporize almost all the volatile fraction forms due to cold dilution in the full dilution tunnel. But the effect on combustion-generated nuclei-mode particles (core) is not clear.

A hypothetical model for diesel nano-particles distribution has been developed depending on the characteristics.

We develop a new nano-particle measurement devices based our new knowledge.

Acknowledgement

This work is supported by the JRTT

This work was done with Dr. Rahman M. Montajir